**MOMENTUM Review**

1. A 0.075 kg mouse runs across the floor with a velocity of 3.2 m/s. What is its momentum?
2. An asteroid has a mass of 12500 kg. It travels through space at 840 m/s. Calculate the momentum.
3. An 800 kg car is initially travelling 15 m/s. It then accelerates at a rate of 2.4 m/s2 for 6 seconds. What is the cars momentum at the end of this time?
4. Consider a 1.2 kg coconut falling from a 5.2 m tree onto a malicious crab. How much momentum is absorbed by the crab’s carapace?
5. Which has more momentum? A 5.5 g bullet traveling 400m/s or a 6.2 kg aardvark travelling 6.6 m/s.
6. A 2 kg cat is rolling down a hill at 5.2 m/s. At the bottom of the hill it is going 13.4 m/s. What is the initial momentum? What is the final momentum? What is the change in momentum? What is the impulse?
7. What is the impulse of a 55 N force exerted over a time interval of 0.001s?
8. What force is needed to change the speed of a 10.0 kg object from 12.6 m/s to 25.5 m/s in a time interval of 5.00s?   
   b) What is the impulse of this force?
9. A mass of 6.3 kg traveling at 6.0 m/s is acted on by a force giving an impulse of (-31.5) N.s. What is the velocity of the mass after the impulse?
10. What force must be imparted to a 0.1 kg baseball to change the velocity from 40.0 m/s to -50 m/s in 0.012 s

b) What is the impulse of this force?

1. An unbalanced force of 25 N acts on an object originally at rest for 5.0 s. If the object has a mass of 0.15 kg, what speed does the object obtain at the end of the 5.0 s?
2. When Phreddy Physics serves a tennis ball, it leaves his racket with a velocity of 65.0 m/s. If the balls mass is 0.06 kg and is in contact with the racket for 0.030s,
   1. what is the average force acting on the ball?
   2. what is the impulse of this force?
3. A 90.0 kg fullback is running at 5 m/s and is stopped by a tackler in 0.5 s. Calculate:
   1. the original momentum of the fullback.
   2. the impulse imparted to the tackler.
   3. the average force exerted on the tackier.
4. Calculate:
   1. the impulse 'suffered' by a 70.0 kg man who lands on firm ground after jumping from a height of 5.0 m. (hint: find the speed at which the man hits the ground)
   2. What average force would be exerted on the man in the collision if he bent his knees and absorbed the fall over 0.15 s?
   3. What average force would be exerted on the man in the collision if he locked his knees and absorbed the fall over 0.0002 s?
5. A rifle bullet of mass 0.06 kg leaves the muzzle of a rifle with a velocity of 600 m/s. If the rifle is loosely held, what will it's velocity be if it's mass is 3.0 kg?
6. A railroad car of mass 12000 kg is traveling at a speed of 6.0m/s when it collides with an identical car at rest. If the two cars lock together, what is their common speed after collision?
7. A bowling ball of mass 8.0kg is traveling at 10.0 m/s when it strikes a 1.5 kg bowling pin. After being hit by the ball, the pin flies backwards (in the direction the ball was traveling) at 20.0 m/s, while the ball continues forward in the same direction. What is the velocity of the ball after impact?
8. A loaded freight car of mass 5000 kg breaks away and moves down the track with a speed of 4.0 m/s. If finally collides with two stationary freight cars of mass 1500 kg (each). If they all couple together, at what rate do they move down the track?
9. An ice hockey player weighing 900 N skates with a velocity of 8.0 m/s in order to slam into a member of the opposing team who is standing still. They become tangled together and move down the ice with a velocity of 5.0 m/s. 'What is the weight of the other player?
10. A 53.0 kg skateboarder on a 2.0 kg board is coasting along at 1.6 m/s. If the skateboarder collides with another stationary skateboarder of mass 43.0 kg who is on an identical skateboard. The two become entangled and coast off in the direction of motion of the 53.0 kg boarder. What is their new velocity?
11. A 1.5 x 103 kg car traveling at 44.0 m/s collides head on with a 1.0 x 103 kg car traveling at 22.0 m/s in the opposite direction. If the cars stick together on impact, what is the velocity of the wreckage immediately after impact?
12. Colin the inventor designs a lightweight gun that shoots heavy bullets. The 50.0 N bullets leave the 40.0 N gun with a velocity of 200.0 m/s. a. What is the recoil velocity of the gun?   
    b) Should Colin patent his invention? Explain
13. A proton traveling at 1.0 x 107 m/s collides with a stationary particle and bounces back with a velocity of 6.0 x 106 m/s. The particle moves forward at a speed of 4.0 x 106 m/s. If the proton has a mass of 1.67 x 10-27 kg, what is the mass of the particle?
14. A large compressed spring is placed between a 4000kg railway car and a 6000 kg boxcar at rest. The spring is released and the two cars move off in opposite directions. If the heavier car moves at 2.4 m/s, how fast will the other move?
15. Describe three things that you know about the constellation Orion.
16. A 0.20 kg golf ball, moving at 80 m/s, hits a watermelon of 10 kg mass at rest on a frictionless table, and sticks in it. How fast does the watermelon move?
17. What is the velocity of Bottle-Lady after the explosion?
18. Consider
19. What is the total momentum before?
20. What is the total momentum after?
21. What is the speed of the apple after?

**ADVANCED**

1. What is the momentum of a 30g walnut that has fallen 3.2 m from a tree branch?
2. Sir Galahad (a knight of weight 666N) falls off his horse and rolls down a hill with an acceleration of 1.5 m/s2. What is Galahad’s momentum after 50m?
3. A very unwise and curious archer shoots an 0.25 kg arrow directly upwards and then forgets about it. 4 seconds later the arrow returns and hits them. What was the initial momentum? What was the final momentum? What was the change in momentum?
4. Consider a 84 kg bicyclist and their 11 kg bicycle, that enter a puddle of gelatinous goo travelling 14 m/s. The goo brings them to a stop in 5.4 s. How much force was delivered by the goo? In what distance did they stop?
5. The mass of the earth is 5.98 E24 kg. The average radius of Earth’s yearly orbit about the Sun is 1.50 E11 m. With these two pieces of information calculate the momentum of the Earth.
6. If a photon (piece of light) is massless how can it have momentum?
7. A diver of mass 62 kg leaps from a 10 m diving board into a pool. 1.5 seconds later the diver is stopped by the water. What is the impulse imparted on the diver?
8. A hammer of mass 0.62 kg is moving at 22 m/s. It strikes a nail and drives it 8 cm before stopping. What force did the hammer exert?
9. Calculate the final velocity in each scenario.
10. What is the velocity of the combined masses after the collision?
11. How fast must an average human of 58 kg horizontally jump off a 1.2 kg skateboard in order for the skateboard to reach the wall that is 13m away. The coefficient of friction between the skateboard and floor is 0.35.
12. In the process of beta decay an electron (9.11 E-31 kg) is ejected from the nucleus of an atom. A carbon nucleus (2.01E-26 kg) initially at rest emits an electron that travels 80% the speed of light. What is the speed of the nucleus after the emission?
13. How far does the wreckage travel?

Answer Key ;

1. **1.** 0.24 kg-m/s **2.** 11 x 106 kg.m/s **3.** 23520 kg m/s **4.** 12.11kgm/s **5.** 2.2 < 40.92 **6.** 10.4, 26.8, 16.4, 16.4 **7.** 0.055 N.s **8.a**) 25.8 N **b)** 129 N.s **9.** 1 m/s **10.** -750 N, -9 N.s **11.** 833 m/s **12.** a)130N b)3.9 N **13.** 450, 450, 900 N **14.** 692 N.s, 4619 N, 3.46 E6 N **15.** -12 m/s **16.** 3 m/s **17.** 6.25 m/s **18.** 2.5 m/s **19.** 540 N **20.** 0.88 m/s **21.** 17.6 m/s **22.** -250 m/s **23.** 6.68 E-27 kg **24.** 3.6 m/s **26.** 1.6 m/s **27.** 3.7 m/s **28.** 12.4, 12.4 ,– 6.3 m/s
2. Advanced (1) 0.237kg.m/s (2) 832.8 kg.m/s (3) 4.9, -4.9, -9.8 kg.m/s (4) 246N (5) 1.79 E 29 kg.m/s(6) (7) 868N (8) 1.88 E3N (9) 3.6 m/s (10) 7.47 m/s (11) 0.195 m/s (12) 10878 m/s (13) 2.3 m